SR 18: 180th Avenue SE to Maple Valley (MP 12.57 to MP 16.55)

MONITORING REPORT

USACE 1999-4-00171

Wetland Assessment and Monitoring Program

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Environmental Services Office

SR 18: 180th Avenue SE to Maple Valley 2004 Monitoring Report

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Executive Summary

This report documents the status of the SR 18 Permit Deviation mitigation sites (Map 1.1) with respect to success standards for 2004. SR 18 Jenkins Creek is the original mitigation project, Wetland KA is the violation fill site, and Kendal 2 is the subsequent compensation. The following tables summarize performance criteria and results obtained in 2004.

Site Name	Performance Criteria	2004 Results [1]
SR 18 Jenkins Creek		
	100% survival of planted woody species (all dead material will be replaced)	2003: 87% survival (total count) Dead plants replaced in February 2004 2004: 96% ($CI_{99\%}$ = 94-98% survival)
	$\leq$ 25% cover of *Phalaris arundinacea*	8% ($CI_{80\%}$ = 6-10% cover)
	Control priority noxious weeds	Active control of all undesirable species
	Habitat structures in place	Present
	Wetland hydrology	Present in most areas

SR 18 Kendal 2		
	100% survival of planted woody species	2003: 1910 trees and shrubs planted Dead plants replaced February 2004 2004: 1832 trees and shrubs counted
	$\leq$ 25% cover of *Phalaris arundinacea*	7% ($CI_{80\%}$ = 5-9% cover)
	Control priority noxious weeds	None observed Active control of all undesirable species
	Habitat structures in place	Present
	Wetland hydrology	Present on 2/3 of intended wetland

SR 18 Wetland KA		
	Describe the replanting success	2003: 80% survival (total count) Dead plants replaced in February 2004 2004: 84% survival (total count)

[1] Estimated values are presented with their corresponding statistical confidence interval. For example, 96% ($CI_{99\%}$ = 94-98% survival) means we are 99% confident that the true aerial cover value is between 96% and 98 percent.

List of Acronyms

Acronym	Meaning
CI	Confidence Interval (see Methods and Glossary)
ECY	Washington State Department of Ecology
FAC	Facultative Indicator Status (Reed 1988)
FACW	Facultative Wetland Indicator Status (Reed 1988)
IP	Individual Permit
MP	Mile Post
NWP	Nationwide Permit
OBL	Obligate Wetland Indicator Status (Reed 1988)
SR	State Route
USACE	United States Army Corps of Engineers
WDFW	Washington Department of Fish and Wildlife
WSDOF	Washington Department of Fisheries
WSDOT	Washington State Department of Transportation

Introduction

Infrastructure improvements including highway construction projects, highway interchanges, and bridges have accompanied economic and population growth in the state of Washington. The Washington State Department of Transportation (WSDOT) evaluates the potential for degradation of critical areas that may result from these infrastructure improvements. WSDOT strictly complies with applicable federal, state, and local environmental regulations, including the Clean Water Act and the state "no net loss" policy for wetlands (Executive Order 89-10). Generally, mitigation sites are planned when transportation improvement projects adversely affect critical areas. The WSDOT Wetland Assessment and Monitoring Program monitors these mitigation sites as a means of evaluating compliance with permit conditions and tracking site development.

The purpose of this document is to report the status of Northwest Region WSDOT permit (USACE 1999-4-00171, September 6, 2002) deviation mitigation sites (SR 18 Jenkins Creek, Kendal 2, and Wetland KA) with respect to permit compliance and success standards for 2004 (Map 1.1).

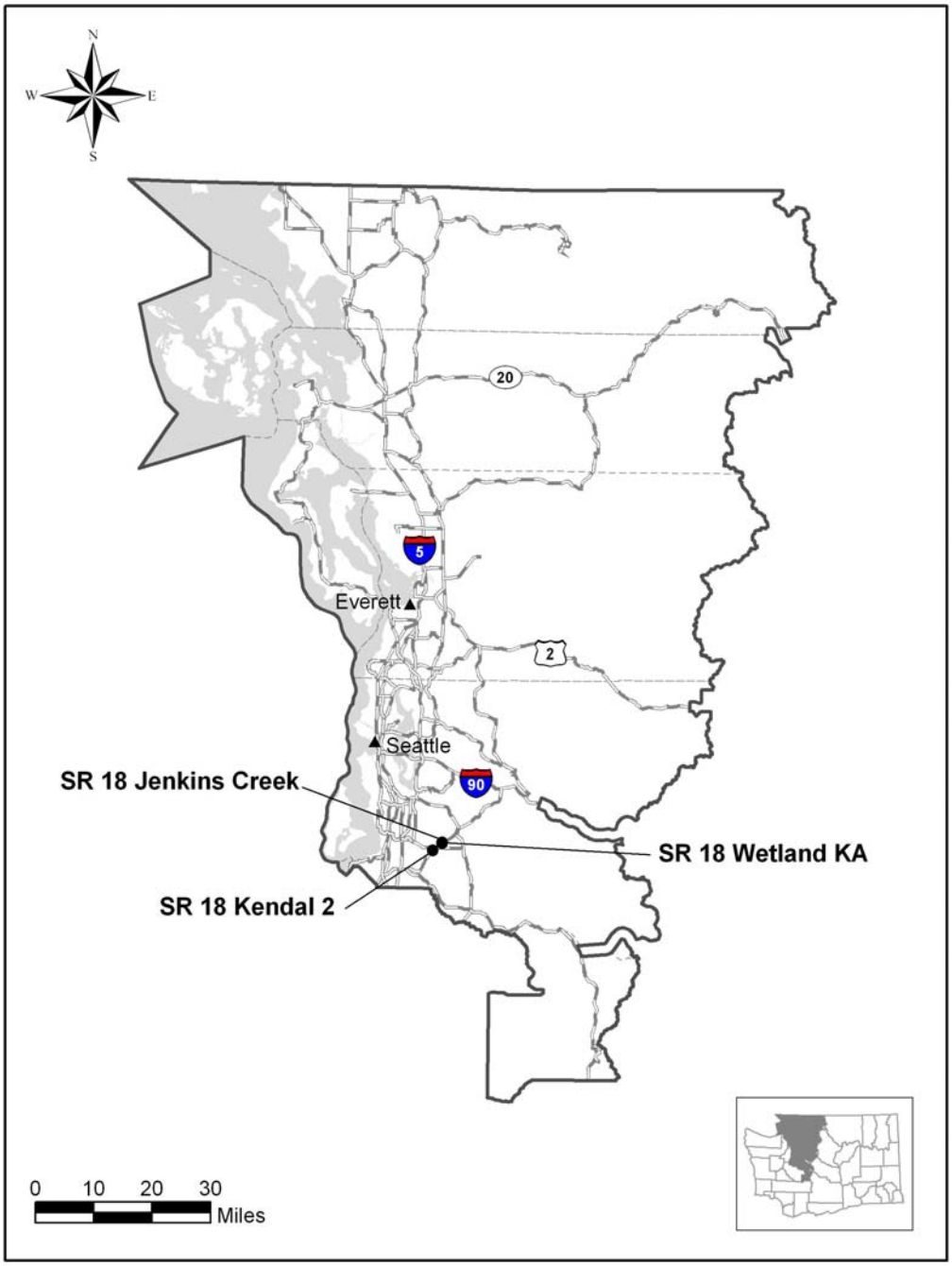
Process

Monitoring typically begins the first spring after a site is planted and continues for the time period designated by the permit or mitigation plan. The monitoring period generally ranges from three to ten years. In special cases sites may be monitored beyond the designated monitoring period.

Monitoring activities are driven by site-specific success standards detailed in the mitigation plan or permits. Data are collected on a variety of environmental parameters including vegetation, soils, hydrology, and wildlife. When data analysis is complete, information on site development is communicated to region staff to facilitate management activities as part of an adaptive management process. Monitoring reports are issued to regulatory agencies and published on the web at:

http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm

Map 1.1 Permit Deviation Sites Monitored in 2004



Methods

Methods used for monitoring mitigation sites change as site requirements and customer needs evolve. Quantitative data collection techniques presently in use are based on standard ecological and biostatistical methods.[2] The Wetland Program's current monitoring methods include the following key elements:

Objective-based Monitoring

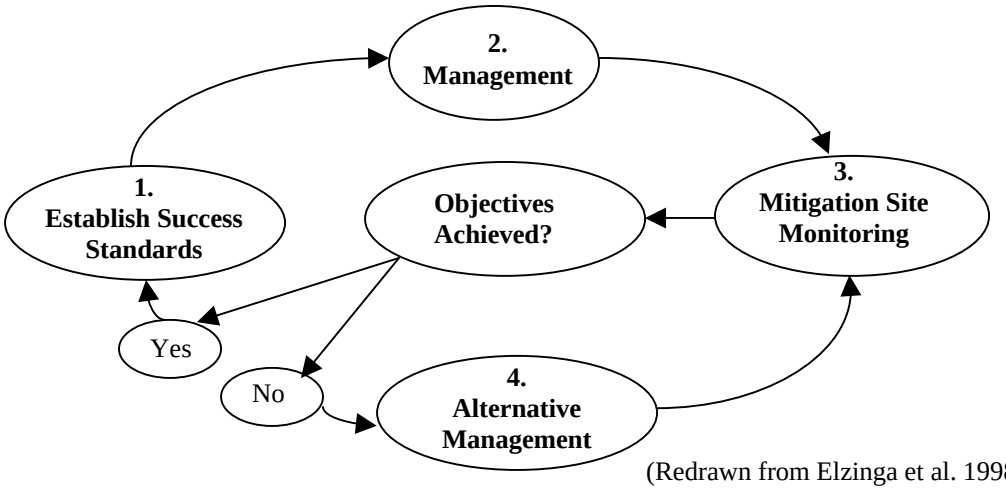
We collect data using a monitoring plan and sampling design developed specifically for each site. The monitoring plan and sampling design address success standards, permit requirements, contingencies, and other considerations as appropriate.

Adaptive Management

The adaptive management process includes four iterative steps:

1. success standards are developed to describe the desired condition,
2. management action is carried out to meet the success standard,
3. the response of the resource is monitored to determine if the success standard has been met, and
4. management is adapted if the standards are not achieved.

Monitoring is integral to the success of an effective adaptive management strategy. Without valid monitoring data, management actions may or may not result in improved conditions or compliance with regulatory permits. Timely decisions, based on valid monitoring data, result in increased efficiency and higher probabilities of success (Shabman 1995; Thom and Wellman 1996). The adaptive management process is illustrated in Figure 2.2.



(Redrawn from Elzinga et al. 1998)

Figure 2.2 The Adaptive Management Process

[2] These methods are based on techniques described in Bonham (1989), Elzinga et al. (1998), Krebs (1999), Zar (1999), and other sources.

Data Collection and Analysis

WSDOT's monitoring approach strives to minimize subjectivity in data collection and increase the reliability of data collection and analysis. Important considerations include appropriate sampling design, sampling resolution, random sampling procedures, interspersion and independence of sample units, and sample size analysis. Our goal is to provide customers with an objective evaluation of site conditions based on valid and reliable monitoring data.

Success Standards and Sampling Objectives

Success standards (or performance standards) are important elements of a mitigation plan. They indicate the desired state or condition of the mitigation site at a given point in time. Conditional permit requirements, if different from success standards in the mitigation plan, are also evaluated during monitoring activities. Some mitigation plans also provide contingencies if a specific undesirable condition occurs. Contingencies typically initiate a management response at the onset of a particular condition, for example, excessive cover by invasive species or insufficient cover by trees and shrubs.

Wetland Assessment and Monitoring program staff thoroughly examine success standards and permit requirements to understand the desired site condition or characteristics to be measured. Six elements are sought in relation to each success standard to ensure measurability of the desired condition: species indicator, location, attribute, action, quantity/status, and time frame. Where one or more of the six elements is undocumented or unclear in the mitigation plan or permit, clarification is sought from region staff.

Success standards are copied verbatim from the mitigation plan in the success standards and sampling objectives section of each site report. Differences in common usage of the terms *aerial* and *areal* has made their interpretation in mitigation plans difficult. We feel that the term aerial better describes the intent of the mitigation plans in most cases. Where we judge the word *areal* has been used arbitrarily in the success standards, we follow it with a (*sic*) notation. The Glossary defines the meaning of these words as used in this document.

Sampling may be required to address success standards unless an efficient and reliable total accounting of the target attribute can be conducted. Sampling objectives are developed to guide the data collection process. Sampling objectives include a confidence level and confidence interval half width.

The results of sampling are presented with the confidence level and confidence interval noted as ($CI_X = Y_1$-Y_2), where CI = confidence interval, X = confidence level, and confidence interval width is expressed as Y_1 low estimate to Y_2 high estimate. For example, an estimated aerial cover provided by woody species reported as 65% ($CI_{80\%}$ = 52-78% cover) means that we are 80% confident that the true aerial cover value is between 52% and 78% (Figure 2.3).

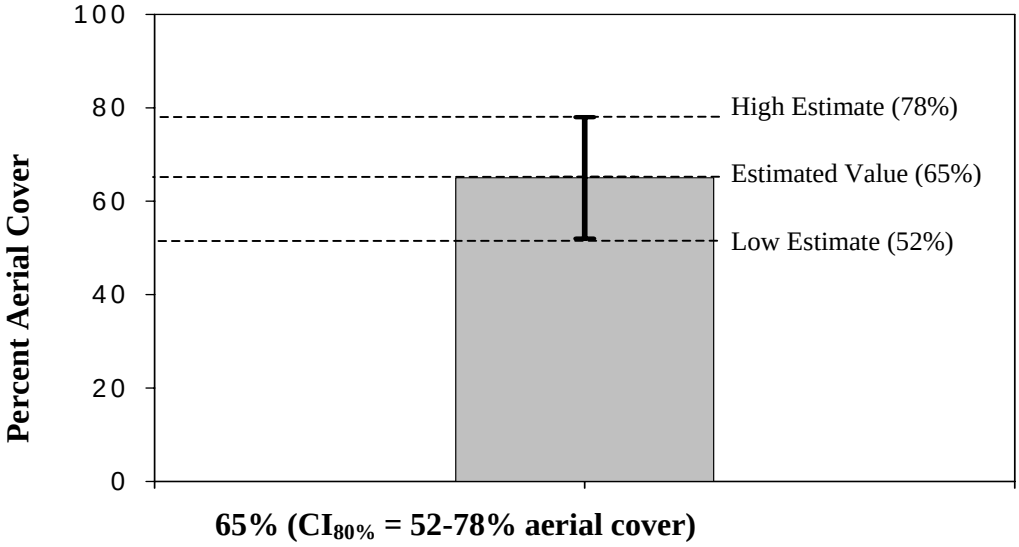


Figure 2.3 Estimated Cover Value Expressed with Confidence Interval Range

For compliance purposes, aerial cover calculations include only areas covered by rooted vascular plants (including floating-leaved species). Areas covered by thallophytes (algae, fungi, bacteria), bryophytes (mosses and liverworts), structures, or aquatic vegetation are not included in aerial cover calculations. Scientific names, most common names, and nativity used in this report were obtained from the *PLANTS Database* (USDA 2003) http://plants.usda.gov. Hydrophytic plant indicator status was obtained from the *National List of Plant Species that Occur in Wetlands: Northwest* (Reed 1988 and 1993). Where noxious weeds are addressed, county specific listings in the *State Noxious Weed List* are referenced (Washington State Noxious Weed Control Board 2004) www.nwcb.wa.gov.[3]

Sampling Design

When sampling is required, a sampling design is developed for the site or zone of interest. Sampling designs can vary from simple to complex depending on the number and type of attributes to be measured. Specific elements such as the size and shape of the site, the presence of environmental gradients, plant distribution patterns, and the amount of time and resources available for monitoring are factors that influence the sampling design. Elements of the sampling design may include the location of the baseline, orientation of transects parallel to the primary environmental gradient, the method of data collection, and the number and type of sample units to be used. Depending on the sampling objective and site characteristics, transects may vary in number, length, and separation distance. Sampling transect locations are determined by using either a simple, systematic, stratified, or restricted random sampling method. A diagram showing the sampling design is typically included in mitigation site reports (Figure 2.4).

[3] In some cases, other nuisance species may be included in invasive cover estimates.

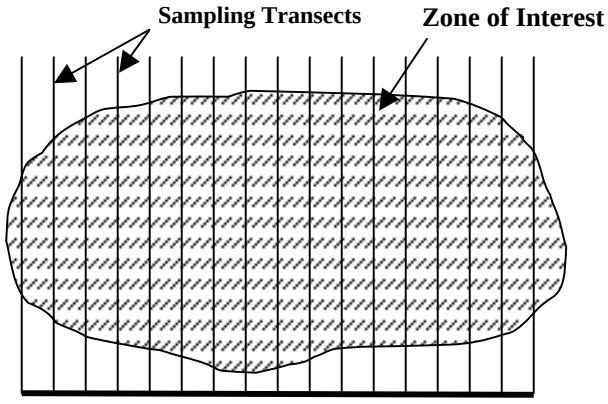


Figure 2.4 Baseline and Sampling Transects

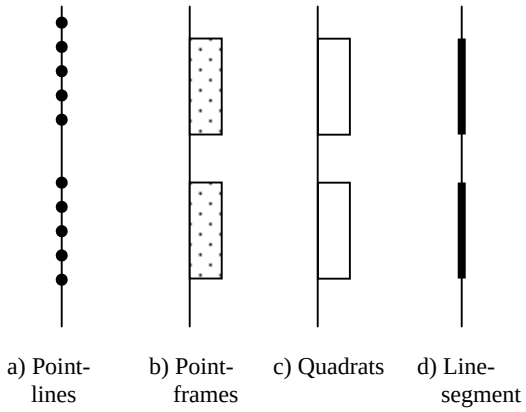


Figure 2.5 (a-d) Sampling Transects and Sample Units

Sample units appropriate to one or more of the methods described below are randomly located on or adjacent to the sampling transects (Figure 2.5 a-d). These drawings are general representations of the actual sampling designs and do not include specific details. Typically, point-lines and point-frames are used to collect herbaceous cover data, quadrats are used to estimate survival and density, and line-segments are used to estimate woody cover.

Point-Line Method

To estimate cover by herbaceous and/or woody species, sample units consisting of a fixed set of points (point-lines) are randomly located along sampling transects (Bonham 1989; Elzinga et al.1998) (Figure 2.5a). Tools used to collect point-line data include point-intercept devices, pin flags, or densitometers. These tools are used to identify point locations. Target vegetation intercepted by the point locator is recorded. If target species are not encountered on the point; bare soil, non-vascular plant, or habitat structure is recorded as appropriate. For each sample unit, cover is determined based on the number of times target vegetation is encountered divided by the total number of points. For example, if invasive species were encountered on 20 points from a sample unit composed of 100 points, the aerial cover of invasive species for that sample unit is 20 percent.[4]

Point-Frame Method

To estimate cover by herbaceous species, point-frames are randomly located along sampling transects (Bonham 1989; Elzinga et al. 1998). A point-frame is a rectangular frame that encloses a set of points collectively serving as a sample unit (Figure 2.5b).[5]

[4] Aerial cover is calculated allowing only one "hit" of target vegetation per point. In this example, two invasive plants encountered at the same point would constitute one "hit." Aerial cover may not exceed 100%.

[5] The WSDOT Wetland Assessment and Monitoring Program typically uses a frame formed with polyvinyl chloride (PVC) pipe. Strings span the frame lengthwise and points are marked on the strings using a standard randomization method.

The point frame is lowered over herbaceous vegetation and data is recorded where target vegetation intercepts point locations. As with the point-line method, a cover value for each sample unit is determined. For example, if facultative-wetland (FACW) and obligate (OBL) species were encountered on 20 points in a point-frame composed of 40 points, the aerial cover of FACW and OBL species for that point-frame sample unit is 50 percent.

Quadrat Method

To estimate survival or density of woody species in an area, quadrat sample units are randomly located along sampling transects (Bonham 1989; Elzinga et al. 1998). Quadrat width and length are based on characteristics of the target plant community and its pattern of distribution. Quadrats are typically located lengthwise along sampling transects (Figure 2.5c). Target plants within a quadrat are recorded as alive, stressed or dead. The success standard or contingency threshold can be addressed with a percent survival estimate of plantings, or a density per unit area of living plantings as appropriate. For example, if eight planted woody species were recorded as alive and two were recorded as dead in a sample unit measuring 1 x 20 meters, the survival of planted woody species for that sample unit would be 80 percent, and the density would be 0.4 live plants per square meter.

Line-Intercept Method

Cover data for the woody species community is collected using the line-intercept method (Bonham 1989; Elzinga et al.1998).[6] Line-segments, serving as sample units, are randomly located along sampling transects (Figure 2.5d). All woody vegetation intercepting the sample unit is identified and the length of each canopy intercept recorded.[7] To calculate an aerial cover value for each sample unit, the sum of the canopy intercept lengths is divided by the total length. For example, if woody vegetation was encountered on 80 meters from a 100-meter sample unit, the aerial cover for that sample unit is 80 percent.

Sample Size Analysis

With each of the above methods, sample size analysis is performed in the field to ensure that an adequate number of sample units are obtained to report the data at the specified confidence level and interval. The sample mean and sample standard deviation are calculated from the data, and sample size analysis is conducted.

The sample size is evaluated using the following equation for estimating a single population mean or a population total within a specified level of precision (Elzinga et al. 1998). A sample size correction to *n* is necessary for adjusting "point-in-time" parameter

[6] Depending on site conditions and other considerations, woody cover data may be collected using the point-line method and a densitometer.

[7] Two or more plants may cover the same length of the sample unit. Overlap is removed from the data before calculating the aerial cover. Aerial cover may not exceed 100%.

estimates.[8] The adjusted *n* value identifies the number of sample units required to report the estimated mean value at a specified level of confidence.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[9]
n = unadjusted sample size

Wildlife Monitoring

Many mitigation plans include goals and objectives that address wildlife. For these sites, incidental wildlife observations are obtained to provide information to support the results of the vegetation monitoring.

Bird Monitoring

Some success standards contain more specific reference to monitoring the avian community. These sites receive three bird surveys conducted during the breeding season (April through mid-July). The point count method (Ralph et al. 1993) is used to document species richness and relative abundance.

Species diversity indices (H) may be calculated from bird survey data using the Shannon-Wiener function (Krebs 1999). Results are expressed as a mean annual species diversity index.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

H' = index of species diversity
s = number of species
p_i = proportion of sample belonging to *i*th species

The following *t* test is used to test the null hypothesis that diversity indices from different years are equal (Zar 1999).

$$t = \frac{H'_1 - H'_2}{S_{H'_1 - H'_2}}$$

H' = index of species diversity
$S_{H'_1 - H'_2}$ = standard error of the difference between species diversity indices H'_1 and H'_2

Amphibian Monitoring

Sites with goals, objectives, or standards referencing amphibians may be monitored using methods adapted from Olson et al. (1997). Methods may include funnel trapping on sites with a water depth of one decimeter or greater. Call surveys and area searches may be used to assess terrestrial components of sites without standing water. Incidental

[8] Adjusted *n* values found in this report were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al 1998).
[9] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

amphibian observations are recorded during other monitoring activities. Potential for amphibian habitat may be qualitatively assessed.

Hydrology Monitoring

Primary and secondary field indicators of wetland hydrology (Ecology 1997) are recorded to address hydrology standards and to aid in future delineation efforts. Wetland mitigation sites are delineated in the spring following the last year of vegetation monitoring so the actual wetland area can be compared to the planned wetland area.

Literature Cited

1. Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons, New York, NY.

2. Ecology (see Washington State Department of Ecology)

3. Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. Bureau of Land Management Technical Reference 1730-1, BLM/RS/ST-98/005+1730. National Business Center, Denver, CO.

4. Executive Order 89-10. WSR 90-01-050. Protection of Wetlands. December 11, 1989.

5. Krebs, C. J. 1999. Ecological Methodology, 2nd edition. Benjamin/Cummings, New York, NY.

6. Kupper, L. L. and K. B. Hafner. 1989. How Appropriate are Popular Sample Size Formulas? The American Statistician (43): 101-105.

7. Olson, D. H., Leonard, W. P., and R. B. Bury. 1997. Sampling Amphibians in Lentic Habitats: Methods and Approaches for the Pacific Northwest. Society for Northwestern Vertebrate Biology, Olympia, WA.

8. Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of Field Methods for Monitoring Landbirds. Gen. Tech. Rep. PSW-GTR-144. Pacific Southwest Research Station, Forest Service, Department of Agriculture, Albany, CA.

9. Reed, P. B. 1988. National List of Plant Species that Occur in Wetlands: Northwest (Region 9). United States Department of the Interior. Fish and Wildlife Service. Biological Report 88 (26.9).

10. Reed, P. B. 1993. Supplement to the National List of Plant Species that Occur in Wetlands: Northwest (Region 9). United States Department of the Interior. Fish and Wildlife Service. Supplement to Biological Report 88 (26.9).

11. Shabman, L. A. 1995. Making Watershed Restoration Happen: What Does Economics Offer? In *Rehabilitating Damaged Ecosystems*, ed. J. Cairns, pp. 35-47. Lewis Publishers, Boca Raton, FL.

12. Thom, R. M. and K. F. Wellman. 1996. Planning Ecosystem Restoration Monitoring Programs. Evaluation of Environmental Investments Research Program, United States Army Corps of Engineers, IWR Report 96-R-23.

13. United States Department of Agriculture, Natural Resources Conservation Service. 2003. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

14. United States Army Corps of Engineers. September 6, 2002. Regulatory Branch Letter (Permit: 1999-4-00171).

15. Washington State Department of Ecology. 1997. Washington State Wetlands Identification and Delineation Manual. Ecology Publication No. 96-94. Olympia, WA.

16. Washington State Noxious Weed Control Board. 2003. Washington State Noxious Weed List. www.nwcb.wa.gov. WA.

17. Zar, J. H. 1999. Biostatistical Analysis, 4th edition. Prentice-Hall, Inc., Upper Saddle River, NJ.

SR 18 Jenkins Creek USACE IP 1999-4-00171

This section summarizes management and monitoring activities completed by the Washington State Department of Transportation at the SR 18 Jenkins Creek (SR 18 180th SE to Maple Valley) mitigation site from the fall of 2003 through the fall of 2004. This site was constructed as compensatory mitigation for a USACE permit deviation, which occurred in Wetland KA during project construction. In August 2004 the Wetland Assessment and Monitoring Program obtained data to address planting success and compare to first year success standards (2003-2004). Activities included assessments of wetland hydrology, invasive vegetation and woody planting survival. Table 2.1 provides general site information and Table 2.2 summarizes monitoring results.

Table 2.1 General Information for the SR 18 Jenkins Creek Mitigation Site

Contract Name and Number	SR 18 180th SE to Maple Valley, C6008	
USACE IP Number	1999-4-00171	
Township/Range/Section (impact)	T.22N/R.6E/S.9,16,17,19,20,21,30	
Mitigation Location	SR 18, south of 256th, west of Jenkins Creek, King County	
Construction Dates	2001-2002	
Monitoring Period	2004 to 2013	
Year of Monitoring	Year 1 of 10	
Area of Project Impact	0.81 acres	
Type of Mitigation	Stream Buffer Restoration	
Area of Mitigation	6.26 acres	
Type of Mitigation	Wetland Creation	Wetland Restoration
Area of Mitigation	0.92 acres	0.56 acres
Type of Mitigation	Wetland Enhancement	Wetland Preservation
Area of Mitigation	4.43 acres	0.35 acres

Table 2.2 Monitoring Summary for the SR 18 Jenkins Creek Mitigation Site

Performance Criteria	Results
Success Standards	
1. 100% survival of planted woody species (all dead material will be replaced)	2003: 87% survival (total count) Dead plants replaced in February 2004 2004: 96% ($CI_{99\%}$ = 94-98% survival)[10]
2. $\leq$ 25% cover of *Phalaris arundinacea*	8% ($CI_{80\%}$ = 6-10% cover)
3. Control priority noxious weeds	Active weed control
4. Habitat structures in place	Present
Permit Requirement	
1. Wetland hydrology	Present in most areas
2. Permanent photo points	See Appendix 2A.1

Success Standards and Sampling Objectives

First year success standards for the SR 18 Jenkins Creek mitigation site were excerpted from *SR 18: 180th Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55) Final Wetland Mitigation Plan* (Antieau and Krueger 2001) and the *SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum* (Brown 2002). Sampling objectives follow the success standard where appropriate. Appendix 2A provides the complete text of the success standards and additional permit requirements for this project. Appendix 2B (Antieau and Krueger 2001) contains the planting plan for the site.

Success Standard 1
At the end of the first growing season all planted material shall be alive and healthy (all dead material will be replaced) (2003-2004).

Contingency
Before the beginning of Monitoring Year One (2004), all dead or unhealthy plants will be replaced. Thus, monitoring 100% survival in Monitoring Year One will be verifying this.

> Sampling Objective 1
> To be 80% confident the true survival of woody species is within 20% of the estimated survival.

Success Standard 2
The enhancement and restoration areas shall contain no more than 25% areal *(sic)* cover by reed canarygrass at any point during the lifetime of the monitoring period.

[10] Estimated values are presented with their corresponding statistical confidence interval. For example, 96% ($CI_{99\%}$ = 94-98% survival) means we are 99% confident that the true aerial cover value is between 94% and 98%.

Sampling Objective 2
To be 80% confident the true aerial cover of *Phalaris arundinacea* (reed canarygrass) (USDA 2003) in the creation areas is within 20% of the estimated cover value.

Success Standard 3
All King County-listed Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the mitigation site.

Success Standard 4
All habitat structures identified on the plan have been placed on the site.

Permit Requirement 1
Creation and restoration areas must be saturated to the surface. Saturation must be to the surface for at least 12.5 percent (30 consecutive days) of the growing season (March 1 through October 31).

Permit Requirement 2
Each year's monitoring report shall include photographic documentation of the project taken from permanent reference points.

Methods

In August 2003, survival of woody species plantings was assessed by conducting a total count (Success Standard 1). Individual trees and shrubs were counted as alive or dead with empty planting wells recorded as dead unknowns.

To address vegetation standards (Success Standards 1 and 2) in 2004, a baseline was located along the west end of the site (Figure 2.1). Thirty-one 150-meter transects were randomly located along the baseline using a systematic random sampling method.

Survival was re-assessed in August 2004 after a late winter replanting. Sampling was conducted by randomly locating a quadrat sample unit (1 x 150m) lengthwise along each of the 31 transects.

To address aerial cover of *P. arundinacea* (Success Standard 2), the point-line method was used. Data were collected along 31 randomly located 150-meter point-line sample units (300 points each).

Sample size analysis confirmed that sufficient sampling had been completed based on the sampling objectives and the desired level of statistical confidence. The following sample size equation was used to perform this analysis.

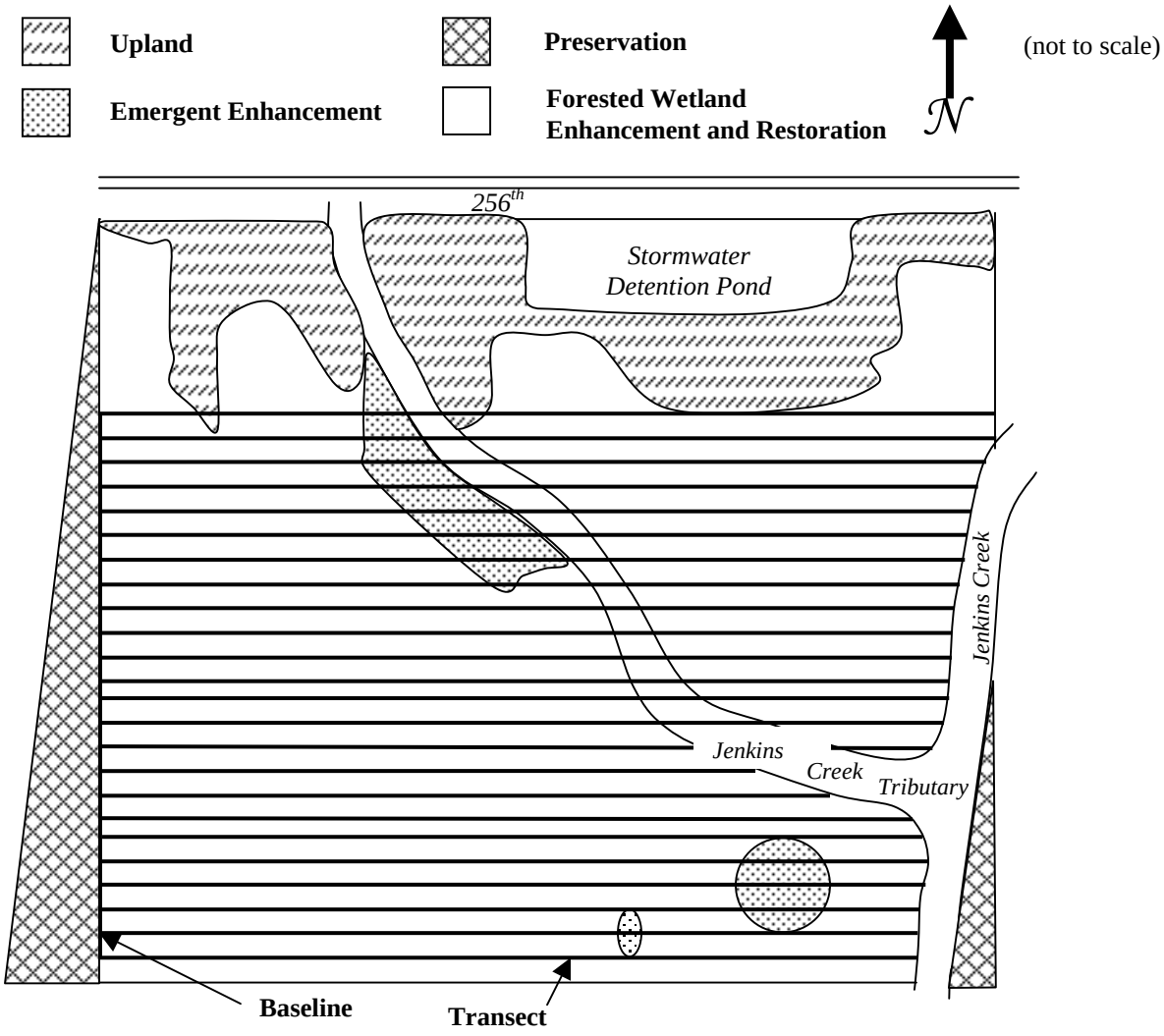


Figure 2.1 SR 18 Jenkins Creek Mitigation Site Sampling Design (2004)

$$n = \frac{(z)^2(s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[11]
n = unadjusted sample size

Habitat structures were counted to address Success Standard 4.

[11] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

To address Permit Requirement 1, primary and secondary field indicators of wetland hydrology (Ecology 1997) were recorded during three site visits in March and April 2004.

Photographs were taken at permanent photo points to address Permit Requirement 2.

For additional details on the methods described above, see the WSDOT Wetland Mitigation Site Monitoring Methods at:
http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

Site Management Activities

Planting of the site was completed in February 2003. A survival assessment was conducted in August 2003 and dead plants were replaced in February 2004.

Undesirable species (not requiring control) identified on site are listed in Table 2.3 by category. Together, these species provide less than 5% cover and will continue to be targeted by weed control efforts.

Table 2.3 Undesirable Species at the SR 18 Jenkins Creek Mitigation Site (Washington State Noxious Weed Control Board 2004)

King County WCB Category	*Scientific Name*	Common Name
Listed Weed of Concern	*Cirsium arvense*	Canada thistle
Listed Weed of Concern	*Cirsium vulgare*	bull thistle
Listed Weed of Concern	*Leucanthemum vulgare*	oxeye daisy
Obnoxious Weed	*Rubus laciniatus*	cutleaf blackberry
Obnoxious Weed	*Rubus armeniacus*	Himalayan blackberry

Results and Discussion

Success Standard 1 – 100% Survival of Planted Woody Species (replace dead material)
This site was originally planted in the spring of 2003. The survival of planted woody species by August 2003 was 87% (total count). The Contingency states that all dead or unhealthy planted woody species will be replaced by the end of year one. Dead plants were replaced accordingly in February 2004. The site was re-assessed in August 2004 with a resulting survival estimate of 96% ($CI_{99\%}$ = 94-98%). These monitoring and plant establishment efforts meet Success Standard 1 and the Contingency.

Success Standard 2 – No More Than 25% Cover by *P. arundinacea*
The estimated aerial cover value of *P. arundinacea* in the wetland was 8% ($CI_{80\%}$ = 6-10% cover). The estimated cover value in 2003 was 12% ($CI_{80\%}$ = 10-14%) These values are well below the 25 percent threshold (Success Standard 2). Most of the cover of *P. arundinacea* is along the edges of the site and the Jenkins Creek tributary. Ongoing weed control efforts on this site appear successful in controlling this species.

Success Standard 3 – Control King County-listed Class A, B-designate, and County-selected Priority Noxious Weeds

For the above categories of weeds, only *Cytisus scoparius* (Scot's broom) and *Senecio jacobaea* (tansy ragwort) (Class B noxious weeds) were observed on site. These species were present at trace levels and have been targeted in ongoing weed control efforts. This meets the requirement of Success Standard 3.

Success Standard 4 – All Habitat Structures Have Been Placed on the Site.

An inventory confirmed that the habitat structures identified on the plans were present on the site.

Permit Requirement 1 – Saturation for At Least 12.5 Percent of the Growing Season

The site was visited on March 3, March 31st, and April 8, 2004. During these site visits, inundation, saturation, or other indicators of wetland hydrology were documented (Figure 2.2). The intended wetland hydrology could not be confirmed in portions of the intended wetland areas. Specifically, the forested wetland creation and restoration area in the south end of the site, and the forested wetland enhancement area in the eastern part of the site were partially dry during each early spring site visit. A reassessment of hydrology and a wetland delineation are scheduled for the spring of 2005.

Figure 2.2 SR 18 Jenkins Creek Mitigation Site (March 2004)

Permit Requirement 2 – Permanent Photo Points

Permanent photo points were established and photographs were taken as specified in the reporting requirements in the Ecology Water Quality Permit (1999-4-00171). A map of the photo point locations and the photographs are included in Appendix 2A

Appendix 2A – SR 18 Jenkins Creek Success Standards

The following excerpt is from the *SR 18: 180th Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55) Final Wetland Mitigation Plan* (Antieau and Krueger 2001) and the *SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum* (Brown 2002). The criteria addressed this year are identified in **bold** font. Other tasks and standards will be addressed in the indicated monitoring year.

Mitigation Goals

The Jenkins Creek wetland/floodplain complex provides important wetland and stream functions, and is a high quality system despite the surrounding levels of development. In the rapidly urbanizing Covington Sub-basin, the Jenkins Creek wetland system provides significant wildlife habitat, including habitat for migration/travel, escape, resting, forage, and reproduction. Jenkins Creek supports salmonid populations. Adjacent wetlands are integral to in-stream habitat, providing wintering habitat, water temperature moderation, inputs of detritus and woody debris, and escape cover.

While the Jenkins Creek system currently provides significant wildlife and fish habitat, the overall quality and quantity of functioning could be improved using restoration and enhancement of degraded wetland and stream areas in that system. The proposed compensatory mitigation for this project is intended to replace wetland types and wetland functions that will be lost due to project construction. Proposed mitigation is anticipated to mitigate loss of the following functions:

Fish and wildlife habitat: mitigation will increase available habitat for fish and wildlife, increase habitat and floodplain connectivity, and provide additional winter refugia for fish.
Food chain support: mitigation will increase available wildlife forage material and detrital input to Jenkins Creek.
Stream temperature moderation: mitigation will increase shade and canopy closure over the streams, while also enhancing potentials for recruiting large woody debris.
Flood water attenuation: mitigation will increase the floodplain area.
Nutrient/contaminant trapping: mitigation will provide an increased area of vegetated floodplain having opportunity to intercept and transform road-runoff contaminants, fertilizers, herbicides, and other pollutants from residential and agricultural activities upstream.

Aside from wetland preservation, a combination of creation, restoration, and enhancement activities will be used to obtain these benefits. Overall, these activities will attempt to achieve 5.71 acres of palustrine forested wetland and 0.20 acre of emergent wetland as mitigation for the loss of 0.81 acre of palustrine forested and emergent wetland.

Objectives and Performance Standards

Objective 1: Wetland Areal Extent and Wetland Hydrology
The wetland mitigation actions involving creation and restoration must demonstrate a total of 1.48 acres or more that support wetland hydrology (Table 4). **Hydrology in zones of creation and restoration will be monitored in Monitoring Years One**, Two, Three, Five, Seven, and Ten. Monitoring wells will be left in place to facilitate hydrologic data analysis during plant establishment.

Performance Standards: Monitoring Years One through Five
PS1. **Creation and restoration areas must demonstrate a total of 1.48 acres or more that support wetland hydrology.**

Monitoring/Delineation Schedule
A determination of areal extent will be made during the hydrology monitoring period using standard wetland delineation methodology using these monitoring data. The boundary and areal extent of the area supporting wetland hydrology will be determined using an instrument survey or other reliable method of determining area.

Potential Contingency Actions
Regrade the site to achieve the required acreage supporting hydroperiods that meet the hydrology criterion for wetlands (Environmental Laboratory 1987)- "hydrology criterion" inundation or saturation within 12 inches of the surface for 12.5% of the growing season March 1-October 31.

Objective 2: Vegetation
The mitigation program is intended to enhance 0.20 acre of emergent wetland (3 percent), enhance 4.23 acres of forested habitat (72 percent), and create and restore 1.48 acres of forested wetland (25 percent) (Table 3). Each of these habitats is expected to be dominated by native plant species. Wetland plant communities are expected to appear to be succeeding toward the intended forested and emergent communities.

Performance standards: Monitoring Year One (one year after planting)
PS2. At the end of the first growing season all planted material shall be alive and healthy (all dead material will be replaced). The enhancement and restoration areas shall contain no more than 25% areal cover by reed canarygrass at any point during the lifetime of the monitoring period.

Performance Standards: Monitoring Year Two and Three
PS3. Three years after planting, emergent wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 60% or more areal cover involving at least three non-invasive herbaceous plant species adapted for life in saturated soil conditions (facultative-wet or wetter). Forested wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 15% or more areal cover involving at least three species of woody plant species adapted for life in saturated soil conditions (facultative or wetter).

PS4. Three years after planting, upland buffer zones will be comprised of a planted and native naturally colonizing plant community with 15% or more areal cover involving at least three woody plant species.

PS5. All King County-listed Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the mitigation site.

Reed canarygrass (a King County Weed of Concern) is expected to be present during the life of this mitigation effort due to the abundant and adjacent source of propagules, as well as the presence of reed canarygrass on the mitigation site. **The enhancement and restoration areas shall contain no more than 25% areal cover by reed canarygrass at any point during the lifetime of the monitoring period.**

Performance Standards: Monitoring Year Five, Seven, and Ten
PS6. Five years after planting, emergent wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 75% or more areal cover involving at least three non-invasive herbaceous plant species adapted for life in saturated soil conditions (facultative-wet or wetter). Forested wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 25% or more areal cover involving at least three species of woody plant species adapted for life in saturated soil conditions (facultative or wetter).

PS7. Five years after planting, the buffer will be comprised of a planted and native naturally colonizing plant community with 25% or more areal cover involving at least three woody plant species.

Monitoring Schedule
Once during the middle part of the growing season in Monitoring Years One, Two, Three, Five, Seven, And Ten.

Potential Contingency Actions
Before the beginning of Monitoring Year One, all dead or unhealthy plants will be replaced. Thus, monitoring 100% survival in Monitoring Year One (Performance Standards PS3) will be verifying this.

If the site does not meet performance standards PS4 and PS5 (Monitoring Year Three), additional planting will be conducted. Live, containerized plant material will be replanted and monitored to assure that coverage meets performance standards S6 and S7 (Monitoring Year Five).

If the site does not meet performance standards PS6 (vegetation not succeeding in directions that displace or weaken reed canarygrass), and PS7 and PS8 (Monitoring Year Five), resource agencies will be consulted for advice on further measures to remedy problems at the site. The monitoring schedule will be extended and such reasonable measures will be conducted as necessary to establish appropriate wetland vegetation. WSDOT will perform all reasonable measures considered necessary to establish and

maintain a functioning wetland/buffer system that meets the goals and objectives of this monitoring plan.

The mitigation plan uses and promotes the growth of native vegetation. **King County Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the site. In the event that reed canarygrass in the enhancement and restoration areas exceeds 25% areal cover at any point during the monitoring period, a range of techniques will be employed to bring the area into compliance. These techniques include hand pulling and off-site disposal, hand-spraying or wiping with Rodeo, flaming, trampling (crushing), and/or mowing.**

Objective 3: Wildlife Habitat
Wildlife cover and forage availability for birds and small mammals should increase substantially. Addition of native plants, logs with rootwads, logs, log rolls, brush piles, and herpetofaunal hibernacula will increase habitat diversity and structure in newly revegetated areas. Generally, the creation, restoration, enhancement, and preservation of forested and emergent wetland habitats are intended to provide feeding, breeding, and resting habitat for birds, small mammals, amphibians, and reptiles. Such activity will also benefit fish in Jenkins Creek and its tributary by reducing water temperatures and contributing detrital and woody debris.

Performance Standards: Monitoring Year One (one year after planting)
PS8. All habitat structures identified on the plan have been placed on the site.

Performance Standards: Monitoring Year Two and Three
PS9. Habitat structures identified in the plans are still in place and functional.

Performance Standards: Monitoring Year Five, Seven, and Ten
None.

Monitoring Schedule
Once during Monitoring Years One, Two, and Three.

Potential Contingency Actions
Install or replace habitat structures that are missing, damaged, lost, or non-functional.

MONITORING PLAN
WSDOT's Wetland Mitigation Monitoring Program (Monitoring Program) uses objective-based monitoring to document success and change in WSDOT's wetland mitigation sites. Monitoring protocols are based on specific objectives written in each project's wetland mitigation plan, combined with evaluation of current site conditions. A customized monitoring program is developed for each site. The Monitoring Program uses a variety of ecological monitoring techniques and protocols, including those outlined in Horner and Raedeke (1989) and in WSDOT (2000b). Many standard techniques such as permanent transect lines, plots, and photo points are still used. However, the number

and placement of those depend on specific site objectives. Locations of photopoints and transects, if used, are not selected until the first year of monitoring. Statistical precision and accuracy are used to determine the number and configuration of transects and sample plots.

The Monitoring Program will begin monitoring hydroperiod in the wetland creation portion of the site immediately after completion of the grading plan, but prior to construction of the planting plan. During this period, hydrology will be monitored at least twice monthly using shallow groundwater wells or other means of observing soil saturation/inundation. After the planting plan has been constructed, Monitoring Year One will commence at the start of the subsequent year. Beginning with the first growing season after construction of the planning plan, the Monitoring Program will monitor the mitigation site for at least ten years. Parameters to be monitored during this ten-year period include hydroperiod and vegetation, as described above.

Reports for the ten-year monitoring period (including a report for each Monitoring Years One, Two, Three, Five, Seven, and Ten) will be issued to the Corps of Engineers Seattle District Regulatory Branch, Washington State Department of Ecology, King County Department of Development and Environmental Services, and other appropriate resource agencies for review and comment. Successful mitigation will be measured by attainment of the performance standards described in this mitigation plan document. Monitoring may be curtailed early or reduced in intensity if the mitigation effort meets the stated performance standards earlier than anticipated.

CONTINGENCY ACTIONS

WSDOT anticipates the mitigation goal will be achieved by accurately completing the grading and planting plans. However, contingency actions, as described above, may be needed to correct unforeseen problems. Such actions may consist of regarding the site in the case of insufficient hydroperiod, or replanting the site in the case of planting failure. However, natural recruitment of native wetland species and upland species (in the buffer) will be counted toward achieving performance standards for Vegetation. Should areal coverage of wetland or buffer plants consistently fall short of desired performance standards, WSDOT will consult with appropriate agencies in determining what additional measures could be implemented to ensure establishment of viable wetland and upland plant communities.

SR 18 Jenkins Creek Permit Requirements

From USACE Regulatory Branch Letter (2002, p.2) (Permit 1999-4-00171)
The performance standard for wetland hydrology listed below supercedes the performance standard described in the "Final Wetland Mitigation Plan, SR 18: 180th Avenue SE to Maple Valley, Washington (MP 12.57 to MP 16.55) by Clayton J. Antieau, wetland Biologist and Paul. W. Krueger, Landscape Designer, and amended by John Maas and Terry Sullivan, WSDOT, Northwest Region" dated January 2001 and "SR 18:

180th Avenue SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum" dated August 15, 2002.

> **Performance Standard 1: Creation and restoration areas must be saturated to the surface. Saturation must be to the surface for at least 12.5 percent (30 consecutive days) of the growing season (March 1 through October 31). Saturation will be measured by observing soil saturation to the surface or by utilizing water wells.**
>
> In sandy soils, water must be standing in the well at 6 inches or less for at least 12.5 percent of the growing season. In non-sandy soils, water must be standing in the well at 12 inches or less for at least 12.5 percent of the growing season.

From Ecology Water Quality and Certification Permit 1999-4-00171 (2000, p. 7) The Applicant shall prepare and submit annual monitoring reports to Ecology's Sarah Suggs and Sandra Manning, P.O. Box 47600, Olympia, WA 98504-7600 no later than December 30th of each year following the first year of project completion. **Each year's monitoring report shall include photographic documentation of the project taken from permanent reference points (see Figure 2A.1).**

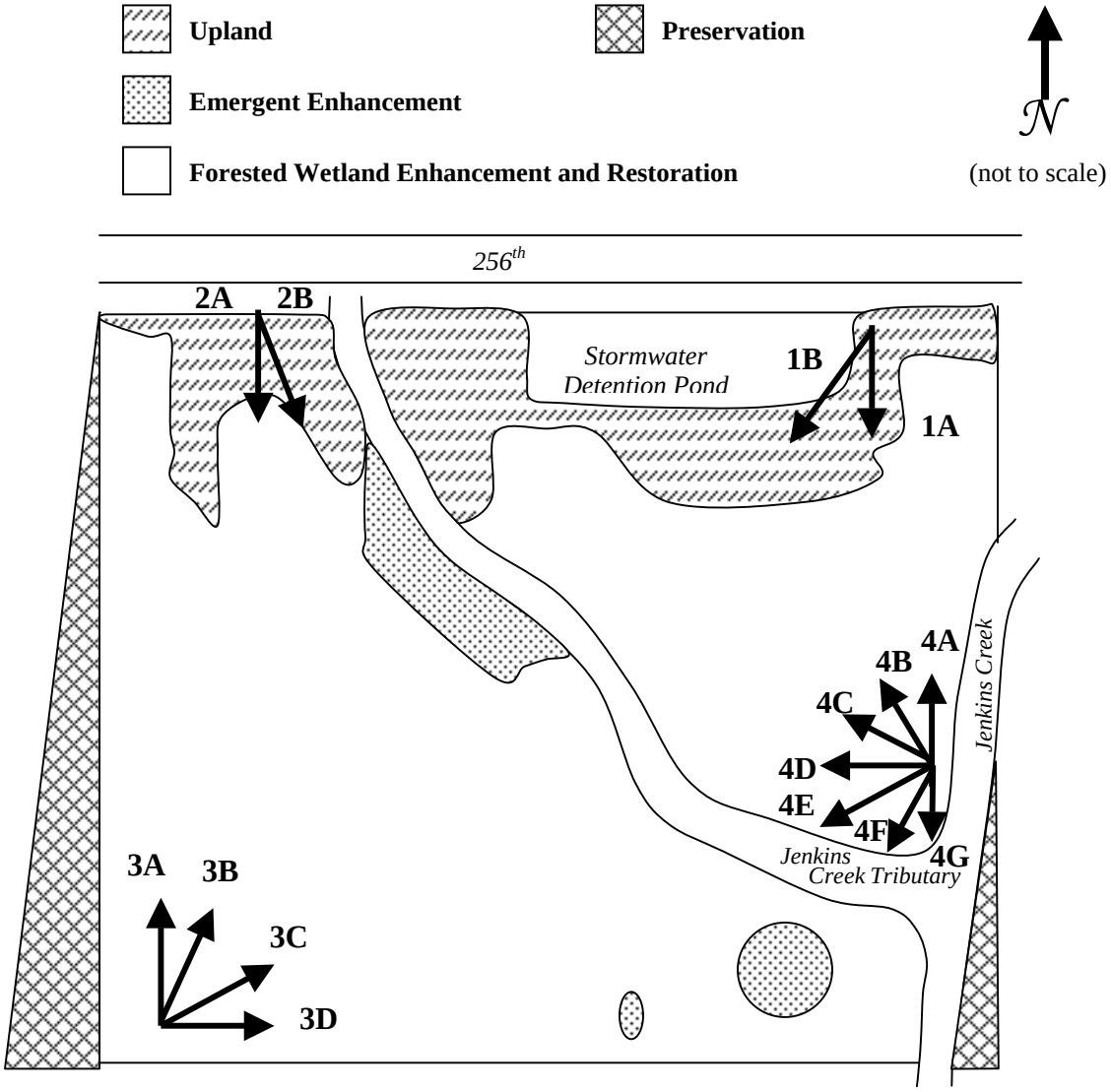


Figure 2A.1 SR 18 Jenkins Creek Site Sketch with Photo Point Locations

Figure 2A.2 Photo Point 1A

Figure 2A.3 Photo Point 1B

Figure 2A.4 Photo Point 2A

Figure 2A.5 Photo Point 2B

Figure 2A.6 Photo Point 3A

Figure 2A.7 Photo Point 3B

Figure 2A.8 Photo Point 3C

Figure 2A.9 Photo Point 3D

Figure 2A.10 Photo Point 4A

Figure 2A.11 Photo Point 4B

Figure 2A.12 Photo Point 4C

Figure 2A.13 Photo Point 4D

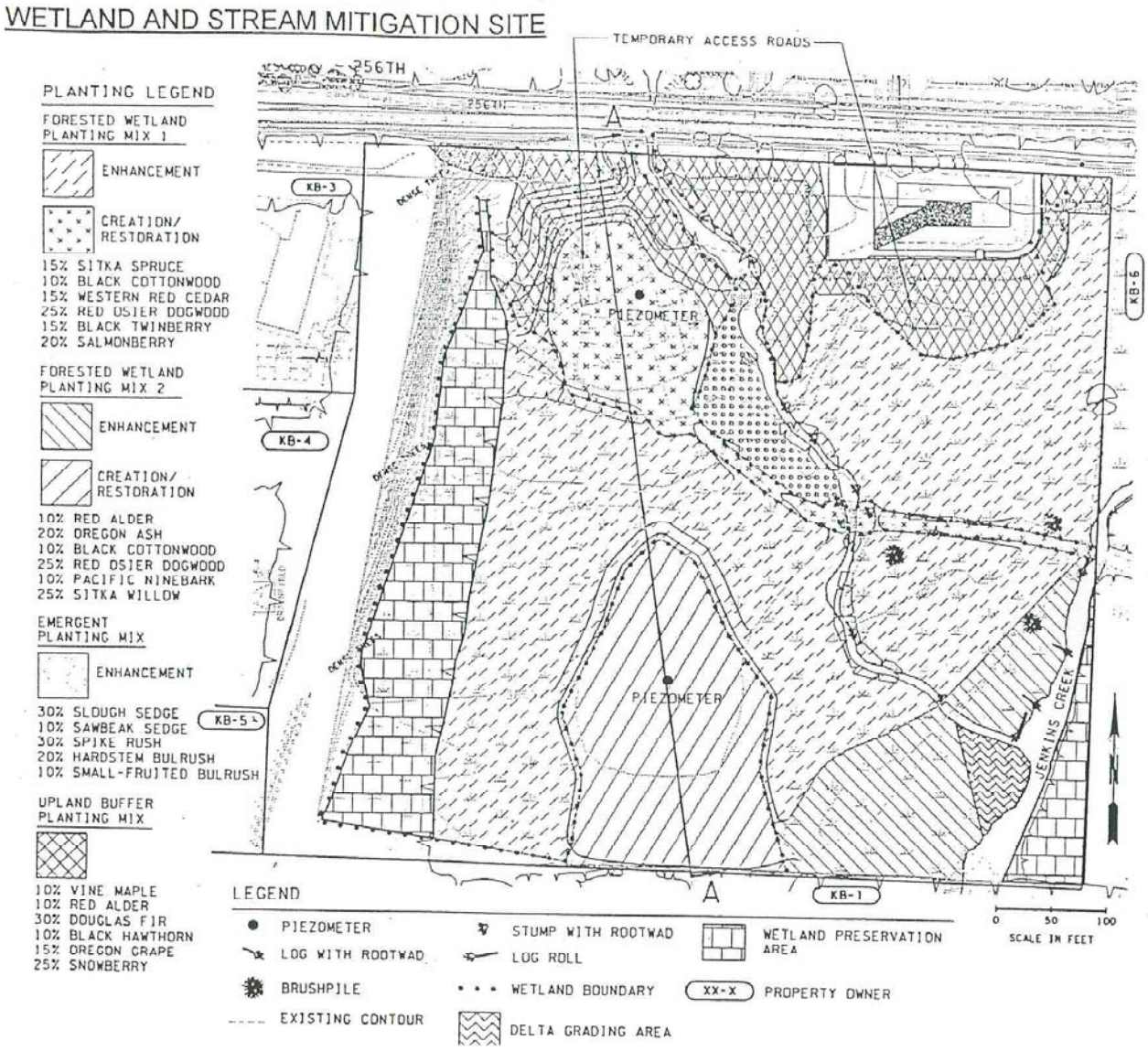
Figure 2A.14 Photo Point 4E

Figure 2A.15 Photo Point 4F

Figure 2A.16 Photo Point 4G

Appendix 2B – SR 18 Jenkins Creek Planting Plan

(Antieau and Krueger 2001)



Literature Cited

1. Antieau, C. J. and Krueger, P. W. January 2001. Final Wetland Mitigation Plan SR 18: Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55). Washington State Department of Transportation, Northwest Region, Seattle, WA.

2. Brown, B. 15 August 2002. SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum. Washington State Department of Transportation, Northwest Region, Seattle, WA.

3. Ecology (see Washington State Department of Ecology)

4. Environmental Laboratory. 1987. United States Corps of Engineers Wetlands Delineation Manual. Wetlands Research Program Technical Report Y-87-1. Seattle, WA.

5. Horner, R. R. and K. J. Raedeke. 1989. Guide for Wetland Mitigation Project Monitoring. Report Number WA-RD 195/.1. Washington State Department of Transportation, Olympia, WA.

6. United States Department of Agriculture, Natural Resources Conservation Service. 2003. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

7. Washington State Department of Ecology. 2000. Water Quality Certification Permit 1999-4-00171. Olympia, WA.

8. Washington State Department of Ecology. 1997. Washington State Wetlands Identification and Delineation Manual. Ecology Publication No. 96-94. Olympia, WA.

9. Washington State Department of Transportation. 2000b. WSDOT Northwest Region Wetland Mitigation Sites 1999 Monitoring Report. Environmental Affairs Office, Olympia, WA.

10. Washington State Noxious Weed Control Board. 2004. Washington State Noxious Weed List. www.nwcb.wa.gov. WA.

SR 18 Kendal 2 USACE IP 1999-4-00171

This section summarizes management and monitoring activities completed by the Washington State Department of Transportation at the SR 18 Kendal 2 (SR 18 180th SE to Maple Valley) mitigation site from the fall of 2003 through the fall of 2004. This site was constructed as compensatory mitigation for a USACE permit deviation, which occurred in Wetland KA during project construction. In August 2004 the Wetland Assessment and Monitoring Program obtained data to address planting success and to assess first year success standards (2003-2004). Activities included assessments of wetland hydrology, invasive vegetation and woody planting survival. Table 3.1 provides general site information and Table 3.2 summarizes monitoring results.

Table 3.1 General Information for the SR 18 Kendal 2 Mitigation Site

Contract Name and Number	SR 18 180th SE to Maple Valley, C6008
USACE IP Number	1999-4-00171
Township/Range/Section (impact)	T.22N/R.6E/S.9,16,17,19,20,21,30
Mitigation Location	Adjacent to SR 18 westbound, west of Big Soos Creek, King Co.
Construction Date	2003
Monitoring Period	2004 to 2013
Year of Monitoring	Year 1 of 10
Area of Project Impact	0.14 acres
Type of Mitigation	Wetland Creation
Area of Mitigation	0.28 acres

Table 3.2 Monitoring Summary for the SR 18 Kendal 2 Mitigation Site

Performance Criteria	Results
Success Standards	
1. 100% survival of planted woody species	2003: 1910 trees and shrubs planted Dead plants replaced February 2004 2004: 1832 trees and shrubs counted
2. ≤ 25% cover of *Phalaris arundinacea*	7% ($CI_{80\%}$ = 5-9% cover)[12]
3. Control priority noxious weeds	None observed Active control of undesirable species
4. Habitat structures in place	Yes
Permit Requirement	
Wetland hydrology	Present on 2/3 of intended wetland

[12] Estimated values are presented with their corresponding statistical confidence interval. For example, 7% ($CI_{80\%}$ = 5-9% survival) means we are 80% confident that the true aerial cover value is between 5% and 9%.

Success Standards and Sampling Objectives

First year success standards for the SR 18 Kendal 2 mitigation site were excerpted from *SR 18: 180th Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55) Final Wetland Mitigation Plan* (Antieau and Krueger 2001) and the *SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum* (Brown 2002). Sampling objectives follow the success standard where appropriate. Appendix 3A provides the complete text of the success standards and additional permit requirements for this project. Appendix 3B contains the planting plan (Moreno 2003) for the site.

Success Standard 1
At the end of the first growing season all planted material shall be alive and healthy (all dead material will be replaced) (2003-2004)[13].

Contingency
Before the beginning of Monitoring Year One (2004), all dead or unhealthy plants will be replaced. Thus, monitoring 100% survival in Monitoring Year One (Performance Standards PS2) will be verifying this.

> Sampling Objective 1
> To be 80% confident the true survival of woody species is within 20% of the estimated survival.

Success Standard 2
The enhancement and restoration areas shall contain no more than 25% areal *(sic)* cover by reed canarygrass at any point during the lifetime of the monitoring period.

> Sampling Objective 2
> To be 80% confident the true aerial cover of *Phalaris arundinacea* (reed canarygrass) (USDA 2003) in the creation areas within 20% of the estimated cover value.

Success Standard 3
All King County-listed Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the mitigation site.

Success Standard 4
All habitat structures identified on the plan have been placed on the site.

[13] The construction of the SR 18 Kendal 2 site was completed in spring 2003. The first monitoring year was considered to be 2004 in order that all first year success standards and contingencies could be adequately and appropriately addressed.

Permit Requirement
Creation and restoration areas must be saturated to the surface. Saturation must be to the surface for at least 12.5 percent (30 consecutive days) of the growing season (March 1 through October 31).

Methods

To address survival of the planted species (Success Standard 1 and Contingency), total counts of trees and shrubs on site were conducted in August of 2003 and 2004. For these counts, each planting was identified and recorded as alive or dead. A separate tally was conducted for native naturally colonizing trees and shrubs.

To assess the cover of *P. arundinacea* and other undesirable species (Success Standard 2 and 3), the point-line method was used. Forty-eight point-line sample units, 20 meters in length (40 points per sample unit) were randomly located across the site (Figure 3.1).

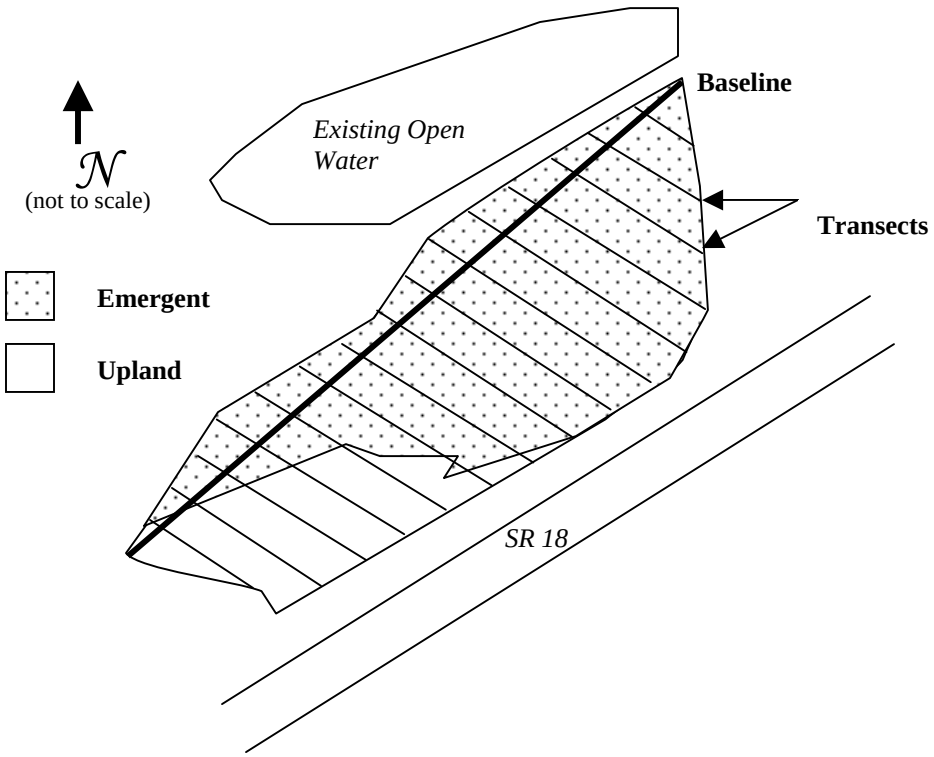


Figure 3.1 SR 18 Kendal 2 Mitigation Site Sampling Design (2004)

Sample size analysis was conducted using the following equation.

$$n = \frac{(z)^2(s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[14]
n = unadjusted sample size

Habitat structures were counted to address Success Standard 4.

To address the Permit Requirement, primary and secondary field indicators of wetland hydrology (Ecology 1997) were recorded during three site visits in March and April 2004.

Management Activities

Planting of the site was completed in February 2003. A survival assessment was conducted in August 2003 and dead plants were replaced in February 2004. Site management and weed control are continuing as needed.

Results and Discussion

Success Standard 1 – 100% Survival of Planted Woody Species

An assessment of survival was conducted in 2003 and dead plantings were replaced in February 2004. This satisfies Success Standard 1 and the Contingency. Survival was re-assessed in August 2004, and 1426 of 1910 original plantings were observed alive. Additionally, 407 native woody volunteers were identified, for a total of 1833 living trees and shrubs. Natural recruitment primarily consists of *Alnus rubra* (red alder), and *Populus balsamifera* (black cottonwood). Species diversity is high with 14 native species represented as shown Table 3.3. Qualitative observations indicate the tree and shrub community is developing well and beginning to stratify with woody plants ranging from

Figure 3.2 SR 18 Kendal 2 Mitigation Site (2004)

[14] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

one to four meters in height (Figure 3.2). Moisture retention from sheet mulch may be partially responsible for the successful plant establishment and growth at this site.

Table 3.3 Development of Woody Species at the Kendal 2 Mitigation Site

Woody Species	Plantings Alive	Plantings Dead	Counted Volunteers	Total Alive	Total Planted (2003)
Acer circinatum (vine maple)	16	2	0	16	25
Alnus rubra (red alder)	67	1	134	201	120
Cornus sericea (red-osier dogwood)	188	1	0	188	290
Lonicera involucrata (black twinberry)	207	0	0	207	290
Malus fusca (Oregon crabapple, *Pyrus fusca*)	0	0	2	2	0
Physocarpus capitatus (Pacific ninebark)	142	3	0	142	290
Picea sitchensis (Sitka spruce)	24	1	0	24	45
Populus balsamifera (black cottonwood)	74	0	173	247	30
Pseudotsuga menziesii (Douglas-fir)	53	3	0	53	75
Rubus spectabilis (salmonberry)	103	0	4	107	290
Salix spp. (willows)	424	0	88	512	250
Spirea douglasii (Douglas spirea)	0	0	4	4	0
Symphoricarpos albus (common snowberry)	115	0	2	117	175
Thuja plicata (western red cedar)	13	8	0	13	30
Unknown	0	67	0	0	0
Totals	**1426**	**86**	**407**	**1833**	**1910**

Success Standard 2 – No More Than 25% Cover by *P. arundinacea*

The estimated aerial cover on site of *P. arundinacea* is 7% ($CI_{80\%}$ = 5-9% cover). This is well under the threshold of 25% specified in the success standard. *P. arundinacea* is encroaching along the southeast edge of the site. Site managers have been advised to target this species in ongoing weed control efforts.

Success Standard 3 – Control King County-listed Class A, B-designate, and County-selected Priority Noxious Weeds

No King County Class A and B noxious weeds were present on site during site visits. Absence of these species satisfies Success Standard 3.

King County-listed weeds of concern *Cirsium arvense* (Canada thistle), and *Cirsium vulgare* (bull thistle), as well as King County listed obnoxious weeds *Rubus armeniacus* (Himalayan blackberry), and *Rubus laciniatus* (cutleaf blackberry), were all identified on site (Washington State Noxious Weed Control Board 2004). An

aggressive weed control program has kept their combined cover value at less than 1 percent.

Success Standard 4 – Habitat Structures in Place
An inventory confirmed that the habitat structures identified on the plans were on the site.

Permit Requirement – Saturation for At Least 12.5 Percent of the Growing Season
The site was visited on March 3, March 31st and April 8, 2004. During these site visits, inundation, saturation, or other indicators of wetland hydrology were documented over approximately two-thirds of the intended wetland areas. A re-assessment of hydrology and a wetland delineation are scheduled for the spring of 2005.

Appendix 3A - SR 18 Kendal 2 Success Standards

The following excerpt is from the *SR 18: 180th Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55) Final Wetland Mitigation Plan* (Antieau and Krueger 2001) and the *SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum* (Brown 2002). The criteria addressed this year are identified in **bold** font. Other tasks and standards will be addressed in the indicated monitoring year.

5.6 Success Standards

5.6.1 Mitigation Goals

The goal of the proposed mitigation is to replace temporal losses of wetland type, acreage, and functions. The proposed mitigation intends to create 0.28 acre of scrub-shrub wetland. The proposed mitigation site is anticipated to provide the following functions:

- Floodwater attenuation
- This function is provided with increased floodplain area.
- Food chain support
- This function is provided with increased detritus/leafy debris input to Big Soos Creek.
- Wildlife Habitat
- This function is provided with increased vegetative community diversity, increased structural diversity, and installation of habitat structures.

5.6.2 Objectives and Performance Standards

The objectives and performance standards presented in the plan will be maintained for the additional mitigation area ad noted below:

Objective 1. Wetland Areal Extent and Wetland Hydrology

The wetland mitigation action must demonstrate a total of 0.28 acres or more that support wetland hydrology. Hydrology in the wetland creation will be monitored in monitoring years five and ten.

Performance standards: Monitoring Years One Through Ten

PS1. The creation areas must demonstrate a total of 0.28 acres or more that support wetland hydrology.

Monitoring/Delineation Schedule

Same as stated in the plan.

"A determination of areal extent will be made during the hydrology monitoring period using standard wetland delineation methodology using these monitoring data. The boundary and areal extent of the area supporting wetland hydrology will be determined using an instrument survey or other reliable method of determining area."

Potential contingency Actions

Same as stated in the plan.

"Regrade the site to achieve the required acreage supporting hydroperiods that meet the hydrology criterion for wetlands (Environmental Laboratory 1987)- "hydrology criterion" inundation or saturation within 12 inches of the surface for 12.5% of the growing season March 1-October 31."

Objective 2. Vegetation

The mitigation is intended to create 0.28 acres of scrub shrub wetland dominated by native plant species.

Performance standards Monitoring Year One

PS2. Same as stated in the plan.
"At the end of the first growing season all planted material shall be alive and healthy (all dead material will be replaced). The enhancement and restoration areas shall contain no more than 25% areal cover by reed canarygrass at any point during the lifetime of the monitoring period."

Performance Standards Monitoring Year Three

PS3. Same as stated in the plan, except no emergent vegetation will be planted.
"Three years after planting, emergent wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 60% or more areal cover involving at least three non-invasive herbaceous plant species adapted for life in saturated soil conditions (facultative-wet or wetter). Forested wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 15% or more areal cover involving at least three species of woody plant species adapted for life in saturated soil conditions (facultative or wetter)."

PS4. Does not apply to this mitigation site

PS5. Same as stated in the plan.
"All King County-listed Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the mitigation site.

Reed canarygrass (a King County Weed of Concern) is expected to be present during the life of this mitigation effort due to the abundant and adjacent source of propagules, as well as the presence of reed canarygrass on the mitigation site. The enhancement and restoration areas shall contain no more than 25% areal cover by reed canarygrass at any point during the lifetime of the monitoring period."

Perfromance standards: Monitoring Year Five, Seven and Ten

PS6. Same as stated in plan, except emergent vegetation will not be planted.
"Five years after planting, emergent wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 75% or more areal cover involving at least three non-invasive herbaceous plant species adapted for life in saturated soil conditions (facultative-wet or wetter). Forested wetland mitigation areas will be comprised of a planted and native naturally colonizing plant community with 25% or

more areal cover involving at least three species of woody plant species adapted for life in saturated soil conditions (facultative or wetter)."

PS7. Does not apply to this mitigation site.

Monitoring/Delineation schedule
Same as stated in plan.
"Monitoring schedule-Once during the middle part of the growing season in Monitoring Years One, Two, Three, Five, Seven, And Ten."

Potential Contingency Actions
Same as stated in the plan.
"Before the beginning of Monitoring Year One, all dead or unhealthy plants will be replaced. Thus, monitoring 100% survival in Monitoring Year One (Performance Standards PS2) will be verifying this.

If the site does not meet performance standards PS4 and PS5 (Monitoring Year Three), additional planting will be conducted. Live, containerized plant material will be replanted and monitored to assure that coverage meets performance standards S6 and S7 (Monitoring Year Five).

If the site does not meet performance standards PS6 (vegetation not succeeding in directions that displace or weaken reed canarygrass), and PS7 and PS8 (Monitoring Year Five), resource agencies will be consulted for advice on further measures to remedy problems at the site. The monitoring schedule will be extended and such reasonable measures will be conducted as necessary to establish appropriate wetland vegetation. WSDOT will perform all reasonable measures considered necessary to establish and maintain a functioning wetland/buffer system that meets the goals and objectives of this monitoring plan.

The mitigation plan uses and promotes the growth of native vegetation. **King County Class A, B-designate, and County-selected priority noxious weed species will be controlled in the season they are first identified on the site. In the event that reed canarygrass in the enhancement and restoration areas exceeds 25% areal cover at any point during the monitoring period, a range of techniques will be employed to bring the area into compliance.** These techniques include hand pulling and off-site disposal, hand-spraying or wiping with Rodeo, flaming, trampling (crushing), and/or mowing."

<u>Objective 3 Wildlife Habitat</u>
Wildlife cover and forage availability for birds and mammals should increase substantially. The addition of fruit and nut bearing shrubs, brush piles, and root wads will increase habitat diversity and structural complexity in newly vegetated areas. Overall, creating a scrub-shrub wetland community is intended to provide feeding, breeding, and nesting habitat for birds, mammals, and amphibians.
Performance Standards: Monitoring Year One

PS8. Same as stated in plan.
"All habitat structures identified on the plan have been placed on the site."

P.S. Year 2 and 3
PS9. Same as stated in the plan.
" Habitat structures identified in the plans are still in place and functional."

P.S. Year 5, 7, and 10
Same as stated in the plan (none).

Monitoring schedule
Same as stated in the plan.
"Once during Monitoring Years One, Two, and Three."

Potential Contingency Actions
Same as stated in the plan.
"Install or replace habitat structures that are missing, damaged, lost, or non-functional."

5.7 Monitoring Plan
Same as stated in the plan.
"WSDOT's Wetland Mitigation Monitoring Program (Monitoring Program) uses objective-based monitoring to document success and change in WSDOT's wetland mitigation sites. Monitoring protocols are based on specific objectives written in each project's wetland mitigation plan, combined with evaluation of current site conditions. A customized monitoring program is developed for each site. The Monitoring Program uses a variety of ecological monitoring techniques and protocols, including those outlined in Horner and Raedeke (1989) and in WSDOT (2000b). Many standard techniques such as permanent transect lines, plots, and photo points are still used. However, the number and placement of those depend on specific site objectives. Locations of photopoints and transects, if used, are not selected until the first year of monitoring. Statistical precision and accuracy are used to determine the number and configuration of transects and sample plots.

The Monitoring Program will begin monitoring hydroperiod in the wetland creation portion of the site immediately after completion of the grading plan, but prior to construction of the planting plan. During this period, hydrology will be monitored at least twice monthly using shallow groundwater wells or other means of observing soil saturation/inundation. After the planting plan has been constructed, Monitoring Year One will commence at the start of the subsequent year. Beginning with the first growing season after construction of the planning plan, the Monitoring Program will monitor the mitigation site for at least ten years. Parameters to be monitored during this ten-year period include hydroperiod and vegetation, as described above.

Reports for the ten-year monitoring period (including a report for each Monitoring Years One, Two, Three, Five, Seven, and Ten) will be issued to the Corps of Engineers Seattle District Regulatory Branch, Washington State Department of Ecology, King County Department of Development and Environmental Services, and other appropriate resource

agencies for review and comment. Successful mitigation will be measured by attainment of the performance standards described in this mitigation plan document. Monitoring may be curtailed early or reduced in intensity if the mitigation effort meets the stated performance standards earlier than anticipated."

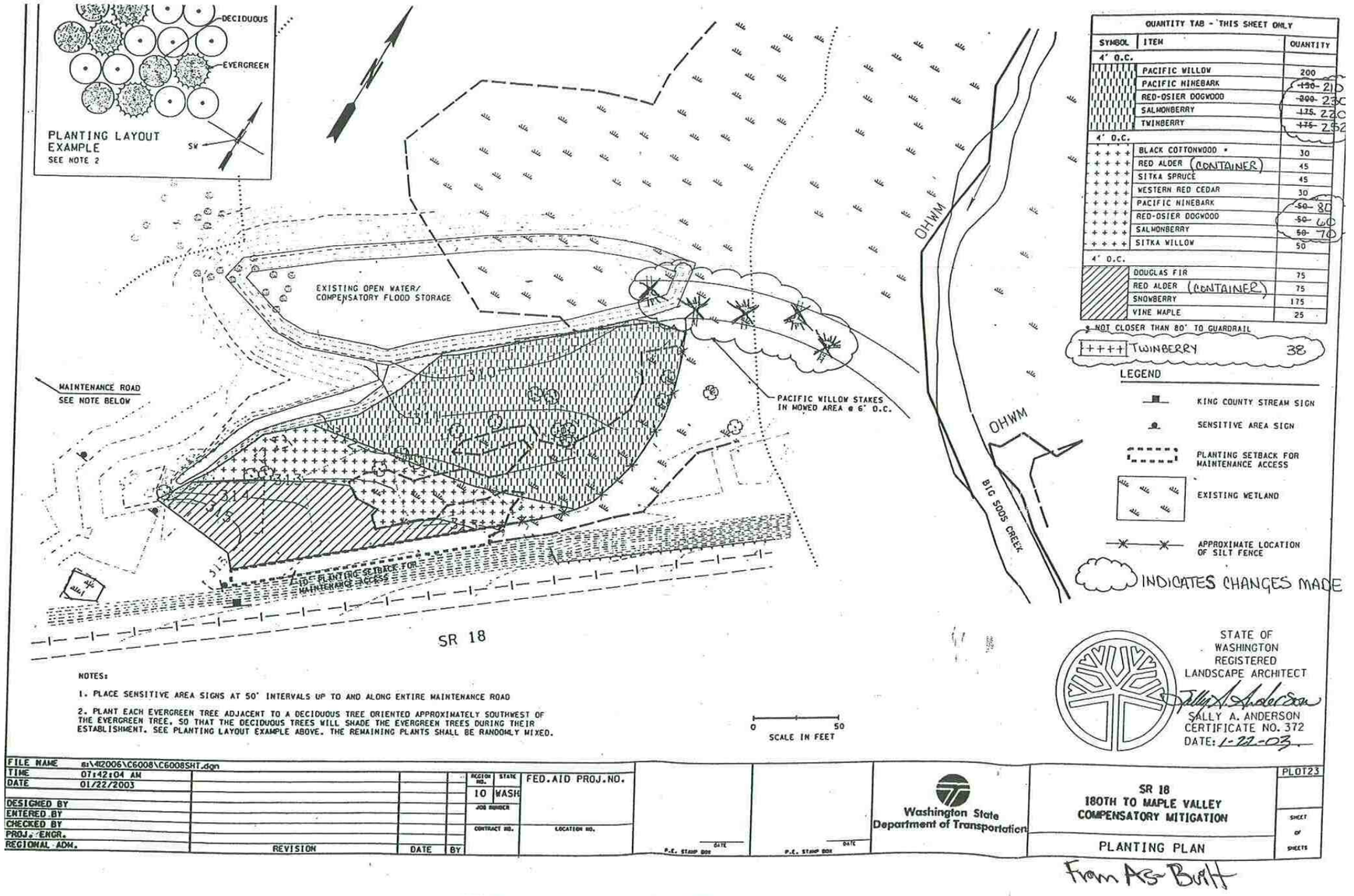
5.8 Contingency Actions
Same as stated in the plan.
"WSDOT anticipates the mitigation goal will be achieved by accurately completing the grading and planting plans. However, contingency actions, as described above, may be needed to correct unforeseen problems. Such actions may consist of regarding the site in the case of insufficient hydroperiod, or replanting the site in the case of planting failure. However, natural recruitment of native wetland species and upland species (in the buffer) will be counted toward achieving performance standards for Vegetation. Should areal coverage of wetland or buffer plants consistently fall short of desired performance standards, WSDOT will consult with appropriate agencies in determining what additional measures could be implemented to ensure establishment of viable wetland and upland plant communities."

SR 18 Kendal 2 Permit Requirements

From USACE Regulatory Branch Letter (2002, p.2) (Permit1999-4-00171)
The performance standard for wetland hydrology listed below supercedes the performance standard described in the "Final Wetland Mitigation Plan, SR 18: 180th Avenue SE to Maple Valley, Washington (MP 12.57 to MP 16.55) by Clayton J. Antieau, wetland Biologist and Paul. W. Krueger, Landscape Designer, and amended by John Maas and Terry Sullivan, WSDOT, Northwest Region" dated January 2001 and "SR 18: 180th Avenue SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum" dated August 15, 2002.

> **Performance Standard 1: Creation and restoration areas must be saturated to the surface. Saturation must be to the surface for at least 12.5 percent (30 consecutive days) of the growing season (March 1 through October 31). Saturation will be measured by observing soil saturation to the surface or by utilizing water wells.**
>
> In sandy soils, water must be standing in the well at 6 inches or less for at least 12.5 percent of the growing season. In non-sandy soils, water must be standing in the well at 12 inches or less for at least 12.5 percent of the growing season.

Appendix 3B - SR 18 Kendal 2 Planting Plan
(Moreno 2003)



Literature Cited

1. Antieau, C. J. and Krueger, P. W. January 2001. Final Wetland Mitigation Plan SR 18: Ave SE to Maple Valley, Washington (MP 12.57 to MP 16.55). Washington State Department of Transportation, Northwest Region, Seattle, WA.

2. Brown, B. 15 August 2002. SR 18: 180th Ave SE to Maple Valley, Washington, Updated Wetland Mitigation Plan Addendum. Washington State Department of Transportation, Northwest Region, Seattle, WA.

3. Ecology (see Washington State Department of Ecology)

4. Horner, R. R. and K. J. Raedeke. 1989. Guide for Wetland Mitigation Project Monitoring. Report Number WA-RD 195/.1. Washington State Department of Transportation, Olympia, WA.

5. Moreno, M. L. 2003. 180th to Maple Valley Compensatory Mitigation Site – Kendall 2 As-Built Report. Maple Valley Project Office Northwest Region, South King Area.

6. United States Army Corps of Engineers. September 6, 2002. Regulatory Branch Letter (Permit: 1999-4-00171).

7. United States Department of Agriculture, Natural Resources Conservation Service. 2003. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

8. Washington State Department of Ecology. 1997. Washington State Wetlands Identification and Delineation Manual. Ecology Publication No. 96-94. Olympia, WA.

9. Washington State Department of Transportation. 2000b. WSDOT Northwest Region Wetland Mitigation Sites 1999 Monitoring Report. Environmental Affairs Office, Olympia, WA.

10. Washington State Noxious Weed Control Board. 2004. Washington State Noxious Weed List. www.nwcb.wa.gov. WA.

SR 18 Wetland KA USACE IP: 1999-4-00171

This section summarizes management and monitoring activities completed by the Washington State Department of Transportation at the SR 18 Wetland KA (SR 18 180th SE to Maple Valley) mitigation site from the fall of 2003 through the fall of 2004. In September 2004 the Wetland Assessment and Monitoring Program obtained data to address requirements regarding a permit deviation, which occurred at this site during project construction. This report has satisfies a request by the USACE that the restoration of Wetland KA be discussed in the yearly monitoring report. Activities included a total count of the woody plantings and a qualitative assessment of the restoration effort. Table 4.1 provides general site information and Table 4.2 summarizes monitoring results.

Table 4.1 General Site Information for the SR 18 Wetland KA Restoration Site

Contract Name and Number	SR 18 180th SE to Maple Valley, C6008
USACE IP Number	1999-4-00171
Township/Range/Section (impact)	T.22N/R.6E/S.9,16,17,19,20,21,30
Mitigation Location	SE corner SR 18at the Jenkins Creek bridge, King County
Construction date	2003
Monitoring Period	2003 to 2013
Year of Monitoring	1 of 10
Area of Project Impact	0.14 acres (Wetland KA)
Type of Mitigation	Wetland Restoration
Area of Mitigation	0.14 acres

Table 4.2 Monitoring Summary for the SR 18 Wetland KA Restoration Site

Permit Requirement	Results
Describe the replanting success	2003: 80% survival (total count) Dead plants replaced in February 2004 2004: 84% survival (total count)

Permit Requirement

The first year permit requirement for the SR 18 Wetland KA restoration site was excerpted from a USACE letter dated September 6, 2002 regarding the permit 1999-4-00171. Appendix 4A provides the complete text of the permit requirement for this site, and Appendix 4B contains the planting plan (Cleveland 2003) for the site.

Permit Requirement
Describe the replanting success of the restoration of Wetland KA

Methods

To address survival of the planted species (Permit Requirement), each planting was identified and recorded as alive or dead. Empty planting wells were recorded as dead unknowns.

Photos documenting conditions at the time of the monitoring visit were also taken to address the replanting success.

Management Activities

Planting of the site was completed in February 2003. A survival assessment was conducted in August 2003 and dead plants were replaced in February 2004. Ongoing weed control activities are planned for the spring of 2005.

Results and Discussion

A total count of planted woody species documented survival at 84% in September 2004. Seventy-six of 90 plantings counted were alive. Table 4.3 shows the results by species. The survival value for 2003 was 80%. This value increased due to replanting in February 2004. A second replanting is scheduled for the spring of 2005.

Table 4.3 2004 Survival of Planted Woody Species at the SR 18 Wetland KA Restoration Site

Species	Alive	Dead	Total	Survival
Fraxinus latifolia (Oregon ash)	23	12	35	66%
Picea sitchensis (Sitka spruce)	10	0	10	100%
Salix species (willows)	38	2	40	95%
Thuja plicata (western red cedar)	5	0	5	100%
Total	**76**	**14**	**90**	**84%**

Deciduous individuals that have grown above the *Phalaris arundinacea* (reed canarygrass) (USDA 2003) are doing well. However, some of the shorter *Fraxinus latifolia* (Oregon ash), and *Salix* species (willows) were hard to find, and appeared stressed under the cover of *P. arundinacea*. Most of the coniferous plantings found on site are healthy and vigorous.

New growth is appearing from the cut stumps on some of the vegetation impacted by the fill violation. These species include *Alnus rubra* (red alder), *Cornus sericea* (red-osier dogwood, *Salix* species (willows), and *Spirea douglasii* (hardhack).

Figure 4.1 shows the developing existing and planted vegetation at this site.

P. arundinacea, *Cytisus scoparius* (Scot's broom), *Rubus armeniacus* (Himalayan blackberry), and *Rubus laciniatus* (cutleaf blackberry) were all identified on site. The tree and shrub community may benefit from weed control scheduled for the spring of 2005.

Figure 4.1 SR 18 Wetland KA (September 2004)

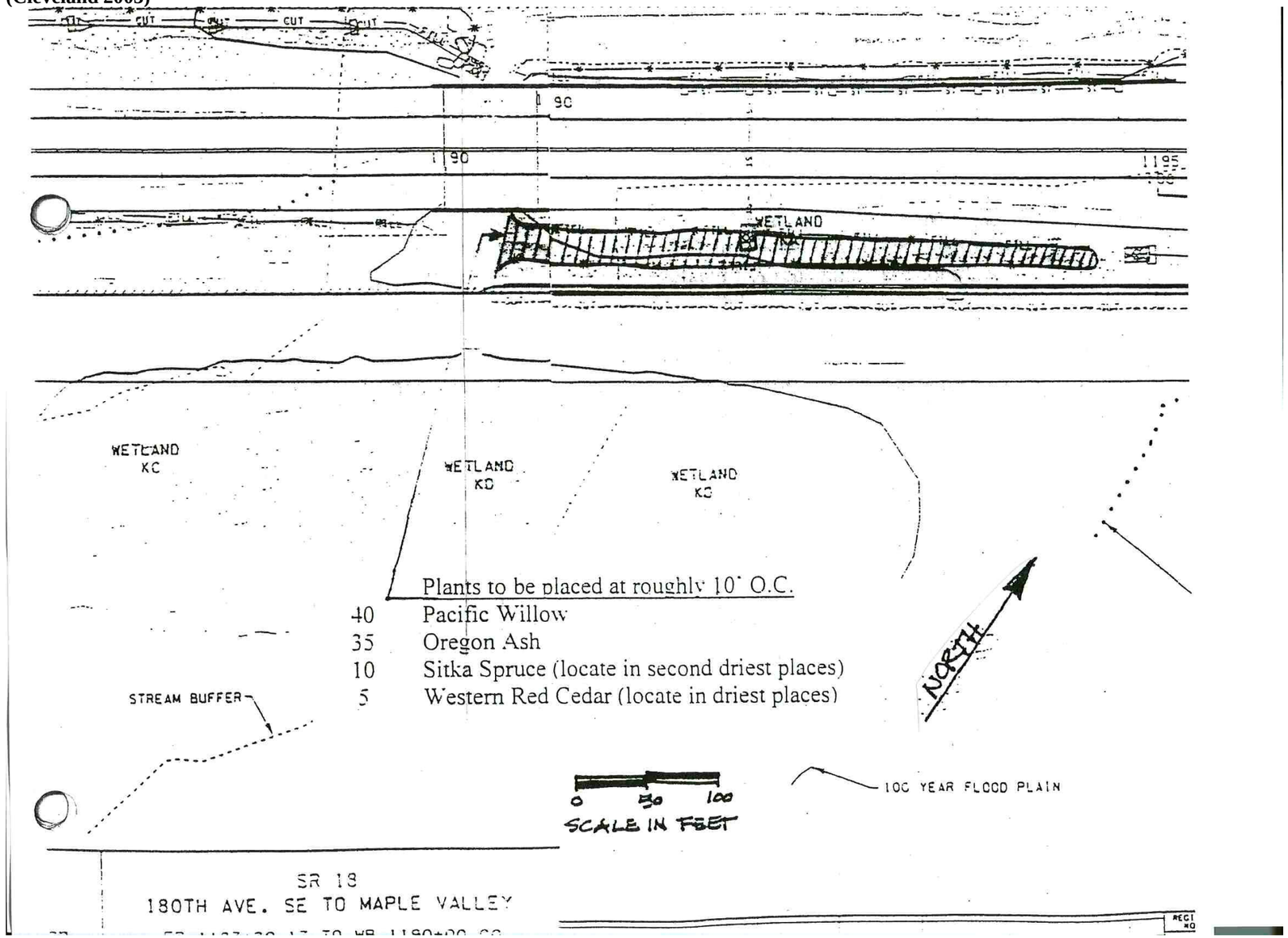
Appendix 4A - SR 18 Wetland KA Permit Requirement

From USACE Regulatory Branch Letter (2002, p.3) (Permit1999-4-00171)
The criterion is identified in **bold** font.

Because this project involves a permit deviation, you must submit annual wetland mitigation monitoring reports for the original and addendum mitigation plan to our office in a separate report than all other Washington State Department of Transportation (WSDOT) wetland mitigation annual monitoring reports. **The monitoring reports you submit for this project must also describe the replanting success of the restoration of wetland KA**

Appendix 4B - SR 18 Wetland KA Planting Plan

(Cleveland 2003)



Literature Cited

1 Cleveland, C. 2003. SR 18 – 180th to Maple Valley Wetland KA Background and Directions. Letter to Jodie Beall dated 24 April 2003.

2 United States Department of Agriculture, Natural Resources Conservation Service. 2003. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

3 United States Army Corps of Engineers. September 6, 2002. Regulatory Branch Letter (Permit: 1999-4-00171).

Glossary of Terms

Abundance (total) – the total number of individuals, cover, frequency of occurrence, volume, or biomass of a species, or group of species, within a given area.

Accuracy – the closeness of a measured or computed value to its true value.

Adaptive management – the process of linking ecological management within a learning framework (Elzinga et al. 1998).

Aerial cover – is the percent of ground surface covered by vegetation of a particular species (or suite of species) when viewed from above (Elzinga et al. 1998). Values for aerial cover are typically obtained from point-line, point-frame, or line-intercept data. Aerial cover does not include overlapping cover of separate plants, thus it does not exceed 100%.

Areal estimates – are made using the known boundary of a feature or statistical population. Areal estimates are often expressed in units of area.

Aquatic vegetation – includes submerged and rooted (*Elodea, Myriophyllum*) or floating (non-rooted) plants (*Lemna, Azolla, Wolfia*). For compliance purposes, these plants are not included in cover estimates. Vascular, rooted, floating-leaved plants *are* included in cover estimates (e.g., *Nuphar, Potamogeton*).

Bare ground – an area that can support, but does not presently support vascular vegetation.

Community – a group of populations of species living together in a given place and time.

Confidence interval (CI) – is an estimate of precision around a sample mean. A confidence interval includes confidence level and confidence interval half-width.

Density – the number of plants per unit area (typically square meters).

Densitometer – a hollow T-shaped polyvinyl chloride (PVC) device that includes horizontal and vertical leveling and a mirror to locate a precise vertical point in space either directly above or directly below the densitometer. Target vegetation intersecting the vertical line of sight through the instrument is recorded.

Herbaceous – with characteristics of an herb; an annual, biennial, or perennial plant that is leaflike in color or texture, and not woody.

Hydric soils – soils formed under the conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register 1994).

Invasive – a plant that interferes with management objectives on a specific site at a specific point in time (Whitson et al. 2001). For monitoring purposes, invasive species include those listed on the current County Noxious Weed List, and on a site-by-site basis, other species may be included (such as *Rubus armeniacus* (Himalayan blackberry)).

Line-segment – a linear sample unit that is used to measure vegetative cover.

Macroplot – usually refers to a relatively large sampling area in which sub-sampling will be conducted, often using quadrats, line-segments or point-lines (Elzinga et al. 1998).

Open water – an area intended to be non-vegetated and permanently inundated as described in the site mitigation or planting plan.

Point-frame – is a square or rectangular quadrat that consists of a set of identified points used to collect vegetation data.

Point-Intercept Device – a tripod that supports a rod that can be leveled and lowered vertically to intercept target vegetation at an identified point.

Point-line – linear series of points comprising a sample unit.

Point-quadrat (points) – a single point, used to sample vegetation data. The point quadrat is theoretically dimensionless.

Population (biological) – all individuals of one or more species within a specific area at a particular time.

Population (statistical) – the complete set of individual objects (sampling units) about which inferences are made.

Precision – the closeness of repeated measurements of the same value.

Quadrat – an area delimited for sampling flora or fauna; the sampling frame itself.

Random sampling – sampling units drawn randomly from the population of interest.

Relative abundance (birds) – the number of individuals per unit of sampling effort.

Relative cover – the relative cover of a plant species (or suite of species) is the proportion of the target species coverage compared to that of all species in the plant community combined (Brower et al. 1998).

Restricted random sampling method – a sampling method that divides the population of interest into equal-sized segments. In each segment, a single sampling unit is randomly positioned. Sampling units are then analyzed as if they were part of a simple random sample (Elzinga et al. 1998).

Sample – a subset of the total possible number of sampling units in a statistical population.

Sample size equations – use sample mean and standard deviation to determine if data have been collected from enough sample units to meet the sampling objectives.

Sample standard deviation – a value indicating how similar each individual observation is to the sample mean.

Sampling – the act or process of selecting a part of something with the intent of showing the quality, style, or nature of the whole.

Sampling objective – a clearly articulated goal for the measurement of an ecological condition or change value (Elzinga et al. 1998). Sampling objectives provide a complement to success standards and describe the desired level of precision for sampling. Elements of a sampling objective include the desired confidence level and confidence interval half-width, or the acceptable false-change error and acceptable missed-change error level.

Sampling units – the individual objects that collectively make up a statistical population.

Standard deviation – a measure of how similar each individual observation is to the overall mean value.

Shrub – a woody plant which at maturity is usually less than six meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

Species richness – the total number of species observed on a site.

Structures – any structure that is not expected to support vegetation during the monitoring period. Structures may include habitat structures, rocks, and other artifacts.

Stratified random sampling method – the population of interest is divided into two or more groups (strata) prior to sampling. Within each stratum the sample units are the same. Sample units from different strata may or may not be identical. Random samples are obtained within each group (Elzinga et al. 1998).

Systematic random sampling method – the regular placement of quadrats, points, or lines along a sampling transect following a random start.

Transect – for vegetation surveys, the transect is a line used to assist in the location sample units (point-lines, quadrats, line-segments or frames) across the monitoring study area.

Tree – a woody plant that at maturity is usually six meters (20 feet) or more in height and generally has a single trunk, unbranched for one meter or more above ground, and more or less definite crown (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

Vegetation structure – the physical or structural description of the plant community (e.g. the relative biomass in canopy layers), generally independent of particular species composition.

Literature Cited

1. Brower, J. E., J. H. Zar and C. N. von Ende. 1998. Field and Laboratory Methods for General Ecology. WCB McGraw Hill, Boston, MA; p.88.

2. Cooke, S. S., (ed.). 1997. A Field Guide to the Common Wetland Plants of Western Washington and Northwestern Oregon. Seattle Audubon Society, Seattle, WA.

3. Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of The United States. United States Department of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

4. Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. Bureau of Land Management Technical Reference 1730-1, BLM/RS/ST-98/005+1730. National Business Center, Denver, CO.

5. Federal Register. July 13, 1994. Changes in Hydric Soils of the United States. Washington, D.C. (current Hydric Soil Definition).

6. Whitson, T. D. (ed.). 2001. Weeds of the West. The Western Society of Weed Science. 9th edition. Grand Teton Lithography, Jackson WY.